REVIEW ON POWER QUALITY IMPROVEMENT BY OPTIMIZATION AND CONVENTIONAL APPROACHES

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Abstract- UPQC (Custom power Devices) with optimized technique like fuzzy logic controller for the distribution power system. Furthermore one can evaluate some more analysis can be done for the custom power devices for the improvement of power quality in different angles like advanced PWM methodologies like sinusoidal, hysterisis (bang – bang) and space vector (symmetrical or asymmetrical) implementations with programmable digital signal processors for the optimum control of the filtering devices through various advanced Artificial Intelligent Techniques like expert systems, Natural language processing, neurofuzzy, genetic algorithms, or swarm intelligence. Controllers like multilevel inverters or matrix converters selection for the custom power devices to improve power quality based on the problem

Keywords: UPQC,power,quality,transmission

I. INTRODUCTION

Power quality is a set of parameters that describes the process of providing electrical power to the user under normal conditions. It determines the continuity of the power supply and characterizes the power supply. When the voltage and current deviates from its normal values, it is called as event. These events occurred because of improper wiring or grounding and unbalanced loads. Five main problems are defined as following: -

1) Under-voltage
2) Over-voltage
3) Outages
4) Electric Noise
5) Harmonic distortion

Under-voltage: The sudden reduction in the AC-voltage at the given frequency is called as sag or under-voltage. On power can lead to the failure of non-linear loads such as power supplies. It is also called brownouts.

Over-voltage: The sudden increase in the AC-voltage at the given frequency is called as swell or over-voltage. The main cause of the swell is start-up or shut down short circuits and bad voltage regulation. The over-voltage affects the data and memory loss, bright light or dim light and display screen shrinkage.

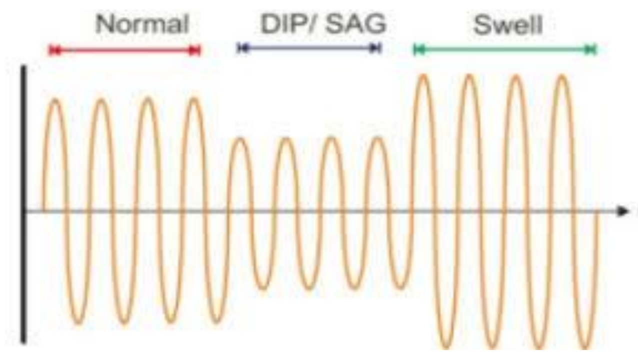

Figure 1.1 Voltage problem occurred due to bad power quality.

Inductive Load – Inductive load is a system which is used to convert the current into a magnetic field. The inductive reactance resists the variation of the current, which causes a delay voltage of the circuit. These are some devices which produce the reactive and inductive loads by including motors, transformers and chokes. When these types of loads are used as a combination of resistive loads and reactive load it reacts as mixed commercial loads and it is consisting of lighting, heating, motors and transformers. The performance of the full system is evaluating using generators, conductors, voltages and other equipment.

1.2 Equipment to Improve Power Quality

There are many devices which are used to improve power and protect devices and electrical disturbances. The following are the devices that are used to develop strategy for better power quality.

TVSS: TVSS stands for Transient Voltage Surge Suppressors**.** It is a device which provides the simplest way to condition power. The transient clamp impulses to a level which is safe for the electronic device. This TVSS system provides the protection to the electrical system against transients. This unit also provides multi-level protection using the service entrance and subpanel. This equipment coordination supplies the smooth voltage to the electric equipment.

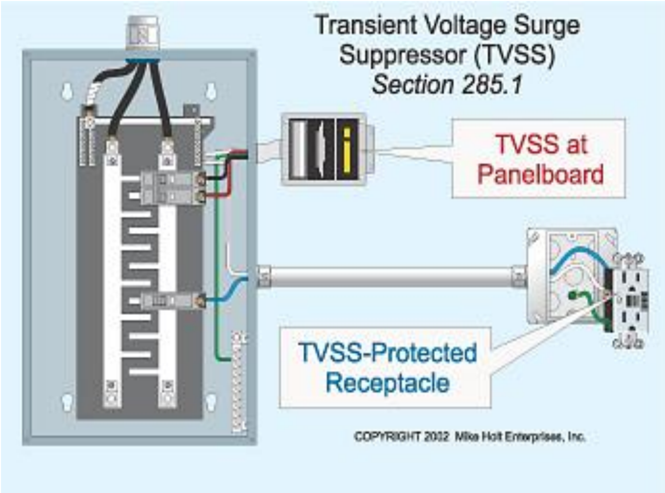

Figure 1.2 Transient Voltage Surge Suppressors

Filters - Filters are the devices which provide the protection against the noises which have high frequency. Filters pass the frequency between the desired and predefined range for low and high frequency and reject the frequency which contains the noisy. The harmonic filters work on the harmonic noises and prevent the loads from fed back into the power source.

Figure 1.3 High Voltage Filters

Isolation Transformers: These devices are used for the isolation and filtering. These devices are mainly used for the reduction of noise by physically separation using magnetic isolation method. These transformers reduce the normal and common noises and does not compensate on power outage and voltage fluctuations.

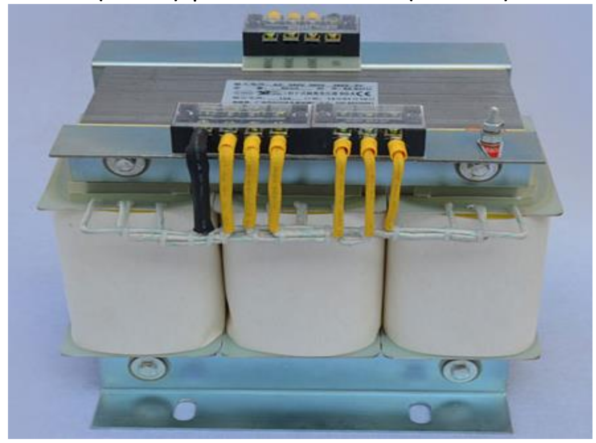

Figure 1.4 Isolation Transformers

Voltage Regulators – These small devices are used to regulate the voltage sags, swells and brownouts. This device is mainly used to maintain the voltage level under all situations and provides a smooth voltage as a input. These are mostly used where the voltage fluctuates the most but total loss of power is uncommon.

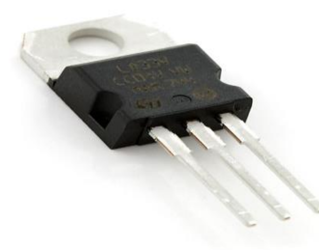

Figure 1.5 Voltage regulator

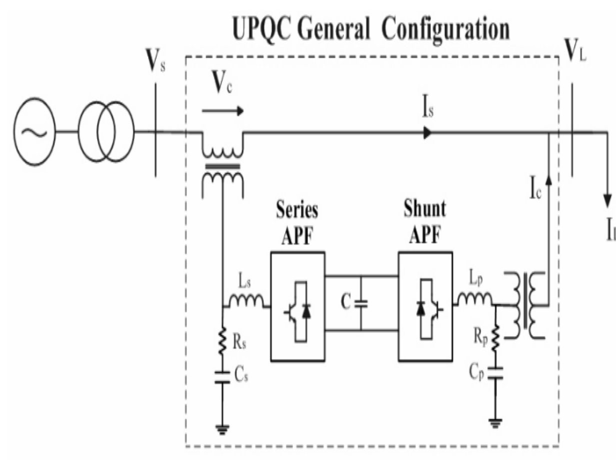

Figure 1.6 UPQC Block diagram

Components of UPQC

- Series APF
- Shunt APF
- Series Transformer
- Low Pass Filter

- High pass filter
- DC interface capacitor

Advantage of UPQC

- Real and reactive power flow would be controlled with help of UPQC.
- Power quality issues such as sag, swell, harmonics and notches will be minimized.
- It is easy to control, because absence of multiple controllers.
- Overall cost of system will be reduced.
- Overall efficiency of the system will be improved.
- Switching frequency is fixed.
- Best option for dynamic conditions.

UPQC Functions

These are the functions performed by the UPQC.

1. Compensating the harmonics in the supply voltage and load current.

2. Elimination of disturbances due to sags / voltage swells on the supply side.

3. Power factor correction on the supply side

4. Maintain the quality of energy despite slight variations in voltage frequency

Distributed Generation (DG) is predicted to play an important role in the electric power system in near future. It is widely accepted that photo voltaic generation is currently attracting attention to meet users' need in the distributed generation market. In order to investigate the ability of photo voltaic (PV) units in distribution systems, their efficient modelling is required. Distributed generation technology is a new, promising way of energy utilization. Where solar power is competitive to stand out from a variety of distributed power and become more developed relatively [1]. The control of grid-connected photovoltaic power generation system is a comprehensive process, which involves not only the technology about solar cell and grid-connected inverter, but also to the control and optimization problems of the system. In the end of the distribution network, the impact on power quality caused by the reactive load in the end of distribution network is more serious than which in centre grids. The fluctuations of reactive load will have a great impact on the supply voltage of power system, there by affecting other loads on this node [8]. The regulation of the PCC (Point of Common Coupling) voltage achieved by the PV system control scheme has a positive impact and important significance for the application of PV. The main circuit topology of three-phase active reactive power compensation device and three-phase grid-connected inverter is exactly the same. Thus, in support of a reasonable control strategy it can be integrated together with both function of grid connection and reactive power compensation control [4]. When it output from photovoltaic cells, the inverter transforms DC into AC current delivered to the power grid, while selectively supply a certain reactive current compensation. When the reactive load fluctuates, the reactive component of the output current can be adjusted to achieve reactive power compensation by the control of PV grid-connected inverter, thus reduce the reactive power provided by large power grids through the transmission line. By reducing the reactive power flow in the grid, it can reduce the energy loss in transmission lines and transformers caused by reactive power transmission. Since the voltage of grid-connected PV system mainly depends on the support of large power grid, when the reactive load fluctuates, a stable system voltage can be achieved by maintaining a constant reactive power output of large power grids [12] [24].

The solar based DG units plays an increasing role in power system of near future. The development of power electronics technology plays a key role in the integration of DG units which change the vertical power system to a horizontal one. DGs can be designed to provide ancillary services to the utility such as reactive power support, load balancing, voltage support, and harmonic mitigation.

Power quality is a very important issue in distribution system. Power quality is simply defined as a quality of electricity i.e. it is a concept that is use to describe the purity of the transferred energy. As per IEEE Std. 1100 Power quality is defined as concept of powering and grounding sensitive equipment in a manner that it is suitable for the satisfactory operation of that equipment. But, the power quality is disturbed or destroyed due to several problems occurring in the electrical network for e.g. voltage sag, Voltage swell, unbalance of voltage and current, harmonics produced in voltage and current flickers transient over voltage supply interruption etc. The allowable source voltage and load current distortion or THD limit as per IEEE standards must be strictly maintained. Harmonic current components create several problems like:

- Increase in power system losses
- Overheating and insulation failures in rotating machinery
- Overheating and insulation failures of conductor, transformers, and cables
- Reactive power burden
- Low system efficiency
- Poor power factor
- System unbalances and causes excessive neutral currents
- Malfunctioning of the protective relays and untimely tripping.

The modern power distribution system is becoming highly vulnerable to the different power quality problems stated above [2], [3] The extensive use of nonlinear loads is further contributing to increased current and voltage harmonics issues. Furthermore, the penetration level of small/large-scale renewable energy systems based on, fuel cell, solar energy, wind energy etc. installations at distribution and transmission networks is increasing significantly. This integration of distributed generation in a power system is introducing new challenges to the electrical power industry to accommodate these systems [4]. For distribution system, UPQC is a most attractive solution for compensating power quality problems. Research is continued for use of UPQC to solve problems such as voltage sag, voltage swell, voltage, correction of power factor and unacceptable levels of harmonics in the current and voltage. The swells are more destructive in nature than sag, UPQC is being studied for mitigation of voltage sag and swell [5], [6]. For example, breakdown of components or equipment due to excessive over voltage during swell condition [7].

II. RELATED WORK

Ali Reaz Reisi, et.al [1] firstly discussed the overview of grid-associated photovoltaic systems (PVs). Secondly, the experts analyzed a deeper detailed look over grid-connected PVs via the technology of active filter. This part explained the modelling of shunt active filter and photovoltaic panel. In other part, the analysts enroll distinct MPPT (maximum power point tracking) methods and also enroll various method for designing DC link in terms of a common bus of photovoltaic system and shunt active filter. In the final part, Simulink/ MATLAB simulations verified the performance of the model proposed.

Beena V, et.al [2] presented a methodology in which the process of enhancing the quality of power was ensured including control of power for grid collective inverter. The work dealt with analyzing and modeling of a grid-associated inverter (transformer less) with reactive and active power control by the control of the phase angle-based inverter output and the amplitude in connection to the voltage of the grid. In conjunction to voltage and current control, the control of power quality was made to curtail the THD i.e. total harmonics distortion. The grid interactive inverter simulation was carried out in the environment of MATLAB/SIMULINK.

Daxa Rathva, et.al [3] presented the concept of compensating the reactive power for grid solar-based PV system. In this type of modeling STATCOM, inverter control, and the controlling strategy using the concept of dq0 transformation of 3-Φ PWM inverter was employed in grid associated PV generation and the PWM inverter control system was used to control the reactive and the active power. In the strategy of inverter control the experts have used various techniques such as PWM, dq0 transformation, and PLL techniques. Using the concept of STATCOM one can eliminate harmonics and compensate reactive power.

Mehrdad Tarafdar Hagh, et.al [4] investigated a grid-connected PV system with injection of active power, compensation of reactive power and the capability of eliminating harmonic current. The electrical equivalent model was presented in the analysis of literature used for implementing the photovoltaic system. In case of non-linear loads, the methods of low frequency-based SRF (synchronous reference frame) were not capable of eliminating the second and third order harmonics that appears in the current of the grid. This study involves a SRF approach based on mathematical analysis in order to compensate the reactive power of the system and to eliminate the harmonic current of non-linearized load with injection of active power. The results based on simulation were presented to verify the feasibility of the system and it also verified the suggested control method.

Abdalla Y.Mohammed, et.al [5] presented the mechanism of interfacing of 3-Φ grid associated PV system. Here, a boost DC-DC converter with MPPT i.e. maximum power point tracking was used for extraction of maximum power gained from the sun and further transfers it to the grid system. Comprehensive implementation and simulation 3-Φ grid associated inverter was presented for validation of the controller proposed for the grid associated PV system.

Kola Yekant, et.al [6] presented a proposed controller that help in utilizing the references of power showing some of the compelling advancements in theoretical part along with a simple controlling topology. DC-DC convertor was meant for connecting the PV module to the Shunt Active Filter DC side. The converter-based switch was mainly controlled by P&O (Perturb & Observe) and MPPT (Maximum Power Point Tracking) algorithms and it helps in eliminating the limitations in traditional system of PV. A MATLAB Simulink based on emulation was shown for validating the benefit of the system proposed.

J Sreedevi, et.al [7] studied various effects grid associated PV system through the process of system simulation in a software, namely, RSCSD software in practical real time basis on the methodology of RTDS (Real Time Digital Simulator). The load-based power factor variation, PV penetration variation, harmonics introduction into the system using PV inverter and the effect of anti-islanding PV system was studied. Finally, grid associated PV system Performance Ratio was evaluated to find the grid connectivity and reliability of PV system.

Ali Rahnamaei, et.al [8] proposed a grid connected PV (Photovoltaic System) that functions as an APF (Active Power Filter) with MPPT (Maximum Power Point Tracking). The filter-based reference current was derived with the help of Fourier Transform. In inverter switches, by considering a reduction of 33%, there was reduction in cost of the grid-connected PV. Using such an approach, it was possible to compensate for the local loads based harmonic and reactive components; moreover, this process helps in injecting active power (generated) into grid at MPPT of of PV cells. During daytime, the system proposed mainly injects the active power to grid and simultaneously compensates for load-based reactive power. In case if there is no sunlight, the inverter of the system performs compensation for local loads only.

Mihai Ciobotaru, et.al [9] introduced a technique of active damping for grid-associated converter system with the help of LCL filter. The adaptive form of Notch filter (NF) considered was mainly implemented in a Canonical Form and it presented accurate discrete-time characterization with advanced technique of matched zeroes and poles. However, it also investigated the NF allowing tuning based on real-time of its bandwidth and resonance frequency that might be important on critical basis in case of LCL filter-based resonance frequency varying due to achievable changes in line inductance or non-linear inductors usage engaging magnetic materials, where the concept of inductance was a function of the current that was applied.

Bhavesh M. Jesadia, et.al [10] presented a grid associated photovoltaic system with the concept of using MPPT (Maximum Power Point Tracking). VSI (Voltage Source Inverter) has been related between the ac grid and PV system-based dc output. The applied control strategy was based on the p-q theory i.e. instantaneous theory of reactive power. During day time, the system sends active power to the grid and simultaneously compensates the load-based reactive power and it also compensates the harmonics. In case of no sunlight, the system available only compensates for harmonics and load-based reactive power. The p-q theory controlling method applicability has been tested over the system test using MATLAB/Simulink simulation.

Li Fusheng, et.al [11] introduced the microgrid structure, integration, composition, control modes, and operation along with microgrid classification using demand function, AC/DC type, and capacity of the system.

Samir Kouro, et.al [12] presented a survey of existing PV based energy conversion system that addressed the configuration system of distinct PV power plants, and the topologies of PV converter have found real world applications for grid-associated systems. Additionally, the technology of PV converter was discussed underlining the possible benefits as compared to the already existing technology. Among all the topologies of the converter, it was found that the most significant appearance has been revealed by the converters of multilevel type, mainly the H-bridge and T-type for high applications of power and also for residential type of applications in the low-voltage range and kilowatt.

Renukadevi V, et.al [13] represented a strategy based on synchronous reference frame and a grid associated PVG i.e. photovoltaic generation system that sends active power to grid, absorbing the reactive power and compensating harmonics generated by the local loads. The models of converter controller were put into action using MATLAB/SIMULINK. Implemented PV model performance was studied related to isolated load. The strategy of synchronous reference frame was used for generating current reference for the process of compensation and traditional PI controllers were used for controlling purpose. The approach helps in utilizing co-ordinate transformations for separation of the harmonic and reactive content present in load current.

SNo.	Author's Name	Tool/Method Used	Paper Title	Application Domain	Inferences
1.	**Ali Reaz Reisi, *et.al***	MATLAB/MPPT i.e. Maximum Power Point Tracking	Optimal Designing Grid-Connected PV Systems	Modelling of shunt active filter and photovoltaic panel.	Analyzed a deeper detailed look over grid-connected PVs via the technology of active filter.
2.	**Mehrdad Tarafdar Hagh, *et.al***	SRF i.e. synchronous reference frame	Control strategy for reactive power and harmonic compensation of three-phase grid-connected photovoltaic system	Grid-connected PV system with injection of active power	The results based on simulation were presented to verify the feasibility of the system and it also verified the suggested control method.
3.	**Renukadevi V, *et.al***	MATLAB/SIMULINK	Harmonic and Reactive Power Compensation of Grid Connected Photovoltaic System	Synchronous reference frame and a grid associated PVG	The approach helps in utilizing co-ordinate transformations for separation of the harmonic and reactive content present in load current.

4.	**Zainal Salam, *et.al***	APF i.e. Active Power Filter	Harmonics mitigation using active power filter: A technological review	Mitigating the harmonics in utility-based power lines	Such a review was also considered in the form of tutorial-type paper as it helps in providing a comprehensive coverage of various technologies of APF by omitting the uninteresting details, but without any loss of the essence of subject-based matter.
5.	**M. El-Habrouk, *et.al***	Power Filters review	A survey of active filters and reactive power compensation techniques	Active electric power filters and reactive compensation of power	The subdivisions and presentation of the power system conditioners, accessible in this paper, display the drawbacks and the merits of every technique and type used in the system.
6.	**G. Grandi, et,al**	MATLAB/SIMULINK	Control methods for active power filters with minimum measurement requirements	Control strategies as a basic control algorithm and minimal current and voltage transducer necessities.	The performance acquired by the suggested control techniques was quite comparable to those of standard alternatives. The experimental results considerably confirmed the numerical results obtained by Simulink of MATLAB.
7.	**Leszek *S.* Czarnecki, *et.al***	CO-Fi (compensating and filtering) circuits	Methods of reactive power compensation and suppression of load-generated harmonics.	Suppression of harmonics generated by load and the compensation of the reactive power	The comparison was made based on the assumption that these circuits were mainly used for suppression of harmonics created by a 6-pulse and a 12-pulse, 3-Φ controlled AC/ DC converters.
8.	**Milan Prodanovic, *et.al***	2 kVA inverter and1Φ laboratory-based network. Kalman Filter	Harmonic and reactive power compensation as ancillary services in inverter-based distributed generation	Control emphasizing either local-voltage distortion or harmonic-line flows	The observers of Kalman were used for achieving an additional benefit of bypassing specific phase-locking mechanism while generating quadrature components that was useful in providing feed-forward compensation and in calculating reactive power instantaneously.
9.	**M.T.L.Gayatri, *et.al***	Comparison of the proposed and existing methods	Reactive Power Compensation in Microgrids: A Survey Paper.	A review of distinct methods of compensating the reactive power in microgrid on the basis of control algorithms, devices, and methods.	Represents various applications and techniques of FACTS devices for compensation of reactive power in microgrids.

III CONCLUSION

To enhance the quality of power has becomes an effective area of research in power system and power electronics. The conditioners are required in the power systems due to high frequency switching and non-linear loads. Unified Power Quality Conditioner (UPQC) is an electronic device which solves the problem of voltage sag and total harmonics distortion problems. The conditioner is a combination of series active and shunt active power filters. The power quality is enhanced by integrating the power filters. The proposed work is done by using fuzzy logic with swarm intelligence approach and proposes a new UPQC system

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